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Acting as the International Preliminary Examination Office

23 March 2005

Madam

IN THE MATTER OF International Patent Application No. PCT/AU2004/000822
in the name of POWERGEN INTERNATIONAL PTY LTD
Entitled REFORMATE ASSISTED COMBUSTION
Our Ref: JMC:DAK:FP19926

The Written Opinion to issue in connection with the above application on 26 August 2004 is to hand and we respond herewith.

The Applicant has considered the citations and explanations provided in the Written Opinion and has prepared a revised set of claims, a copy of which is being forwarded herewith. The revised set of claims take into account the disclosure of each of the citations referred to by the Examiner in the Written Opinion.

During revision, the claims were amended to recite that the gas produced by the hydrogen generator contains hydrogen and at least one other material that is produced along with the hydrogen at the same time in the hydrogen generator. The intentional production of a gas other than hydrogen clearly overcomes of all the citations which require hydrogen to be purified or hydrogen only to be produced by the hydrogen generator.

Additionally, the claims have been amended to recite that the relative amount of the hydrogen and of the at least one other material used in the reformate gas are selected not only in accordance with the nature of the at least one other material but also in accordance with the requirements for hydrogen assisted combustion of that particular other material. This feature allows the selective choice of which combination of gases are produced in the hydrogen generator to satisfy the requirements of hydrogen assisted combustion.

A further restriction of the scope of the claims as revised includes the recitation of a heat exchanger to cool the hydrogen gas blend or reformate gas produced by the hydrogen generator prior to introducing the gas blend into the engine.

It is submitted that the limitations introduced into the revised claims clearly distinguish the present invention from the inventions of all of the references referred to by the Examiner in the Written Opinion.

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It is submitted that all of the revised claims are clearly patentable.

Regarding the substitution of the revised claims would you please delete claim pages 15 to 21 containing claims 1 to 33 as originally lodged with the above application and substitute revised claim pages 15 to 22 containing new claims 1 to 36.

Favourable reconsideration is respectfully requested.

Yours faithfully

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. ³ A method of using a hydrogen containing gas as a fuel, a component of a fuel, a fuel additive or an additive for mixing with a fuel for [hydrogen assisted combustion in] a compression engine characterised in that the hydrogen containing gas [is a gas blend or mixture] produced by a hydrogen generator and comprises hydrogen and at least one other material produced in the hydrogen generation process at the same time as the hydrogen is generated, including the steps of [using the hydrogen generator to produce the hydrogen containing gas blend or mixture, reducing the temperature of the gas blend by passing the gas blend through a heat exchanger, introducing the gas blend or mixture to a compression engine as one component of the fuel and combusting the fuel in the engine, wherein the relative amounts of the hydrogen and of the at least one other material of the gas blend or mixture are selected in accordance with the nature of the at least one other material and the requirements of hydrogen assisted combustion of the engine.

2. A fuel system for a compression engine characterised in that the system comprises a hydrogen containing gas generator for generating a hydrogen gas blend or mixture containing hydrogen and at least one other material at a first temperature, a heat exchanger for reducing the temperature of the hydrogen gas blend or mixture from the first temperature to a second temperature by passing the gas blend or mixture through the heat exchanger prior to introducing the gas blend to the engine wherein the gas blend forms the fuel or one component of the fuel for the engine and wherein the relative amounts of the hydrogen and of the at least one other material of the gas blend or mixture are selected in accordance with the nature of the at least one other material and the

requirements of hydrogen assisted combustion within the engine.

3. A method of operating a hydrogen generation
5 apparatus to produce a hydrogen containing gas, blend or mixture, suitable for use as a fuel, a fuel component or a fuel additive characterised in that the hydrogen containing gas blend or mixture contains hydrogen and at least one other component that is produced in the process
10 at the same time as the hydrogen is produced by a hydrogen generator wherein the operating parameters of the hydrogen generating apparatus are adjusted to provide a preselected or predetermined composition of the gas blend or mixture suitable for use in hydrogen assisted combustion of a
15 compression engine in which the respective amounts of the hydrogen or other component or components are selected in accordance with the nature of the other component or components and with the requirements of an engine to which the gas blend or mixture is introduced in order to
20 facilitate hydrogen assisted combustion of the engine thereby increasing the efficiency and/or performance of the engine.

4. A fuel capable of being used for hydrogen
25 assisted combustion of an engine characterised in that one component of the fuel is a hydrogen containing gas comprising hydrogen and at least one other material that is produced by a hydrogen generator along with the hydrogen during the hydrogen generation process, wherein
30 the relative amounts of the hydrogen and the other material or materials are selected in accordance with the nature of the other material or materials and the requirements of the engine for hydrogen assisted combustion.

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5. A hydrogen containing gas blend or mix suitable for use as a fuel or fuel additive or one component of a

fuel characterised in that the gas blend or mix contains hydrogen and at least one other component in addition to hydrogen in which the other component is produced substantially simultaneously with the hydrogen by a 5 hydrogen generator in which the relative amounts of the hydrogen and the other component is selected in accordance with the nature of the other component and the requirements of the engine for hydrogen assisted combustion within an engine to which the gas blend or mix 10 is introduced.

6. A method of producing at least one component of a fuel for hydrogen assisted combustion of a compression engine in which the fuel includes a hydrogen containing 15 gas characterised in that the hydrogen gas is a gas blend or mixture produced by a hydrogen generator and comprises hydrogen and at least one other material that is produced along with the hydrogen in the hydrogen generation at the same time the hydrogen is generated including the steps of 20 producing the hydrogen containing gas blend or mixture, cooling the gas blend or mixture by passing the gas blend or mixture through a heat exchanger, introducing the cooled gas blend or mixture into the compression engine as at least one component of the fuel wherein the relative 25 amounts of hydrogen and the at least one other material of the gas blend or mixture are selected in accordance with the nature of the at least one other material and the requirements for hydrogen assisted combustion.

30 7. A gas blend or method according to any preceding claim in which the gas blend or mixture is produced by a hydrogen generator characterised in that the non hydrogen components of the gas produced by the hydrogen generator do not all require full removal prior to combustion of the 35 gas in a compression engine using hydrogen assisted combustion but that the gas blend or mixture containing the other component or components can be used as a fuel or

fuel additive.

8. A method or apparatus according to any preceding claim characterised in that the hydrogen generator is an 5 electrolysis apparatus, a fuel cell, a fuel processor, a reformer, a cold fusion apparatus or other apparatus for producing hydrogen along with one or more other materials.

9. A method or apparatus according to claim 8 10 characterised in that the fuel cell is a proton exchange fuel cell, a solid oxide fuel cell, an alkaline fuel cell, a direct methanol fuel cell, a molten carbonate fuel cell, a phosphoric acid fuel cell or a regenerative fuel cell.

15 10. A method or apparatus according to claim 9 or 10 in which the hydrogen generator is a reformer in which steam is used to heat a fuel as it passes over a catalyst provided in the hydrogen generator to produce the hydrogen together with the at least one other material to form the 20 gas blend or mixture in the form of a reformatre gas.

11. A method or apparatus according to claim 10 characterised in that the fuel and steam are cracked by passage through the hydrogen generator to form the 25 reformatre gas or hydrogen containing gas blend or mixture.

12. A method or apparatus according to claim 10 or 11 characterised in that the reformer reforms a hydrocarbon fuel including petrol, diesel, gasoline or the 30 like to the reformatre gas or hydrogen containing gas blend or mixture with the aid of steam.

13. A method or apparatus according to any preceding claim characterised in that the at least one other 35 material is at least one or more of oxygen, nitrogen, water, ethanol, carbon dioxide, carbon monoxide, hydrocarbons, methanol, methane or combinations thereof.

14. A method or apparatus according to claim 13 characterised in that the hydrocarbon material produced in the hydrogen generator is a paraffin or paraffin-like hydrocarbon containing saturated bonds.

15. A method or apparatus according to claim 13 or 14 characterised in that the hydrocarbon is a C₁-C₂₀ hydrocarbon, preferably a C₂-C₁₂ hydrocarbon, more preferably a C₄-C₁₀ hydrocarbon and more preferably a C₆ hydrocarbon, including mixtures of such hydrocarbons and combinations of at least one or more such hydrocarbons.

16. A method or apparatus according to any one of claims 13 to 15 characterised in that the methanol, methane or similar materials produced in combination with the hydrogen gas are produced from a fuel material such as diesel, petrol, canola oil or the like.

17. A method or apparatus according to any preceding claim characterised in that the hydrogen gas blend or mixture produced by the hydrogen generator contains from about 0-50% by volume of hydrogen, preferably 30-40% by volume hydrogen and preferably 35-48% by volume hydrogen.

18. A method or apparatus according to any preceding claim characterised in that the gas blend or mixture includes from about 0-25% by volume of carbon monoxide, preferably 3-5% by volume carbon monoxide, more preferably 4-5% by volume carbon monoxide.

19. A method or apparatus according to any preceding claim characterised in that the gas blend or mixture includes up to about 5% by volume, typically 1-4% by volume, preferably 2-3% by volume of hydrocarbon.

20. A method or apparatus according to any preceding

claim characterised in that the amount of carbon dioxide contained in the gas mix or blend is up to about 25% by volume, preferably 5-15% by volume and more preferably 3-10% by volume.

21. A method or apparatus according to any preceding claim characterised in that the gas blend or mixture contains the balance of nitrogen.

10 22. A method or apparatus according to any preceding claim characterised in that the ratio of individual components in the gas blend or mixture is controlled to be a preselected amount in accordance with the requirement of hydrogen assisted combustion for the particular component.

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23. A method or apparatus according to any preceding claim characterised in that operation of the hydrogen generator is adjusted to produce a desired ratio of hydrogen to the at least one other component in the gas mixture or blend formed by the hydrogen generator.

24. A method or apparatus according to any preceding claim characterised in that operation of the hydrogen generator is adjusted by altering parameters including one or more of the following, the composition of the materials introduced to the hydrogen generator, the velocities of gases of the various components, the temperature of operation of the hydrogen generator, the pressure of operation of the hydrogen generator, the velocity of gas being passed through the generator, the catalyst being used in the generator, the amount of exposure of the reactor to the catalyst, the type of hydrogen generator used, the nature and composition of the other component produced simultaneously with the hydrogen, the amount of cooling of the gas blend before it is introduced into the engine.

25. A method or apparatus according to any preceding claim characterised in that the hydrogen generator in the form of a reformer is operated at a temperature of from 100°C-1000°C, preferably from 200°C-900°C, more preferably from 220°C-800°C.

OK 8
OK 10

26. A method or apparatus according to any preceding claim characterised in that the hydrogen generator is operated at a pressure of from about 1-5 bar, preferably from about 1-3 bar and more preferably from about 2 bar.

27. A method or apparatus according to any preceding claim characterised in that the catalyst used in the hydrogen generator is nickel, platinum or materials containing nickel or platinum or combinations thereof.

28. A method or apparatus according to any preceding claim characterised in that the gas mixture or blend is added directly to the engine or indirectly to the engine after cooling.

29. A method or apparatus according to any preceding claim characterised in that the gas mixture or blend is added to a mixing chamber prior to being introduced into the engine.

30. A method or apparatus according to any preceding claim characterised in that the compression engine is a diesel engine.

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31. A method or apparatus according to any preceding claim characterised in that the system includes one or more heat exchangers to cool the gas blend or mixture or to cool the gas being recycled to the hydrogen generator.

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32. A method or apparatus according to any preceding claim characterised in that the gas blend or mixture is

added separately to the engine or mixer or in combination with one or more other components of the fuel for the engine, preferably the reformate gas, fuel and any other components required for combustion are introduced to the 5 engine in a single feed line.

33. An apparatus or method in accordance with any preceding claim in which the fuel for the compression engine is introduced to the engine separately from the 10 hydrogen containing gas blend or mixture required for hydrogen assisted combustion.

34. An apparatus or method in accordance with any preceding claim characterised in that the fuel is diesel 15 fuel, petrol, gasoline or kerosene.

35. An apparatus or method in accordance with any preceding claim characterised in that the source of hydrogen and/or the other component produced by the 20 hydrogen generator is a hydrocarbon fuel including diesel, petrol, gasoline or the like.

36. A method or apparatus substantially as hereinbefore described with reference to the accompanying 25 drawings.